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The environmental efficiency of non-certified organic farming in China: A case study of paddy rice production ☆

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ABSTRACT

This case study compares the environmental efficiency of non-certified organic and conventional rice production in southern China. Using plot-season level survey data, we test the existence of a "technology gap" between the two types of production, and calculate their environmental efficiency scores based on the level of pure nitrogen use, which is considered as an environmentally detrimental input within the framework of the stochastic frontier analysis. Our analysis reveals that organic farming loses its environmental performance at high nitrogen levels and that during the initial conversion period to organic farming newly converted organic farmers increase the use of external nutrients such as nitrogen to compensate for potential yield losses. These results highlight the uncertainty with which conventional farmers initially tend to view organic farming. However, we find that the experience gained by organic farmers over time helps them increase and maintain the environmental efficiency. We warn against the rapid expansion of organic farming and recommend more technical support and strict nutrient regulation to foster the environmental efficiency of organic farming.

1. Introduction

Achieving the balance between yield and the preservation of the agro-environment has always been the biggest challenge in agricultural development. Within this context, the debates about the sustainability of conventional and organic farming have never ceased (Avery, 1998; Badgley et al., 2007; Connor, 2008; Pretty & Hine, 2001). This debate is now becoming a critical and urgent issue in the 21st century, as the ever-increasing world population requires higher agricultural yields while the deterioration of the agro-environment is becoming more and more serious due to modern agriculture's excessive dependence on environmentally detrimental inputs.

Advocates of organic farming argue that given its exclusion of synthetic inputs, i.e., pesticides, herbicides and fertilizers, organic farming is the more environmentally friendly method. Evidence shows that it has significant environmental benefits in terms of agricultural pollution reduction, soil and water conservation, soil fertility recovery, ecological health and biodiversity improvement. This

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argument has been supported by world institutions who promote organic farming on a global scale (FAO, 2002; Hine, Pretty, & Twarog, 2008; IFAD & Damiani, 2002; Kilcher, 2007; Twarog, 2006; Willer, Rohwedder, & Wynen, 2009; WorldBank, 2009). On the other side of the debate, critics of organic farming firstly stress its lower productivity. Studies show that conversion to certified organic farming could reduce agricultural productivity by 20–50% in Europe and North America (Avery, 1998; Connor, 2008; Mayen, Balagtas, & Alexander, 2010).

Moreover, an often neglected concern involves the pollution of organic nutrients. Indeed, excessive use of external nutrients from organic sources also has a negative environmental impact. For example, the leaching of organic nitrates can cause water pollution, and ammonia volatilization of animal manure is a primary source of greenhouse gas from agriculture (Kirchmann et al., 1998; Pretty, 1995). Therefore, to evaluate agricultural sustainability, one must take into account both agricultural productivity and efficient use of external nutrients. While many studies have focused on the productivity of organic farming (Avery, 1998; Badgley et al., 2007; Connor, 2008; Pretty & Hine, 2001), little attention has been given to the study of nutrient use in organic farming, especially for non-certified organic farming in developing countries.[1]

In the literature of efficiency study, (Reinhard, Lovell, & Thijssen, 1999) propose an indicator of environmental efficiency (hereafter referred to as EE) which is defined as the ratio of minimum feasibility to the observed use of an environmentally detrimental input at a given output level. In other words, the EE indicator measures the efficient use of environmentally detrimental inputs in agriculture production. This measure is appropriate for the evaluation of organic farming systems and provides useful insights into their environmental performance compared to conventional farming systems. In this paper, we contribute to the literature by calculating an environmental efficiency measure to evaluate smallholder paddy rice production in a Chinese village, where non-certified organic farming was introduced in 2005 in the context of the New Rural Reconstruction movement (Renard & Guo, 2013). Specifically, we focus on the efficient use of pure nitrogen, the most important nutrient input for paddy rice production. Meanwhile, it is also the biggest pollutant to air and underground water resulting from agricultural production in China (Ju, Kou, Christie, Dou, & Zhang, 2007; Zhu & Chen, 2002).[2]

Using plot-season level survey data and agronomic experiment data that we gathered ourselves in the village, we firstly test the hypothesis of a "technology gap" between non-certified organic and conventional farming to determine the right production function specification. Using a Stochastic Frontier Analysis (SFA) approach, we then calculate EE scores for both organic and conventional plots and then compare the scores. Finally, we compare the calculated environmental efficiency scores between organic and conventional farming. The panel structure of data (five seasons from 2008 to 2010) also allows us to investigate the evolution of environmental efficiency over time.

Our case study demonstrates that for smallholder rice production, conversion to organic farming does not reduce the actual rice yield if chemical fertilizers are successfully substituted with organic nutrients and there is no significant "technology gap" between organic and conventional farming in poor areas. However, organic farming is not necessarily more environmentally efficient than conventional farming at high nutrient levels, which is mainly due to the inexperience of farmers newly converted from conventional to organic farming, especially during the initial conversion period. Therefore, to maintain the environmental efficiency of organic farming, more external support such as technical training and environmental education is needed to accompany farmers during the conversion period.

The remainder of this paper is organized as follows. Section 2 presents the organic farming project in the village. Section 3 describes the methodological framework and empirical method. Section 4 gives details of the data. Section 5 discusses the main results and Section 6 concludes.

2. Organic farming in Sancha village

Originally dedicated to produce high quality products for exportation, organic farming has now become a rural development strategy in China. Since 2003, vibrant organic communities have been observed in rural China in conjunction with the New Rural Reconstruction social movement that was initiated by scholars, students and social activists. Diverse models such as farmer's co-ops, farmer-participatory development and Community Supported Agriculture (CSA) projects have recently emerged to promote organic farming in China (Day, 2008; Jia'en & Jie, 2011). In this study, we will focus on one of these alternative models in southern China.

The study area is located in Sancha village (109.01E/22.73N), a small village in Hengzhou county of Guangxi province (see Fig. 1).[3] Due to the abundant water resources and tropical climate, paddy rice is one of the most important crops in this region. Since the 1960s, machinery and modern chemical inputs have been promoted in southern China. However, given its remoteness and poverty, Sancha village maintains its old tradition of paddy rice production, i.e., two crop seasons of rain fed culture, cattle tillage and the use of cow dung fertilizer. The average chemical fertilizer application level is about 16.76 kg per mu (1 mu = 1/15 ha) in the village, which is much lower than the average provincial level of 26.24 kg per mu.[4] Therefore, both the traditional agricultural practice and the well preserved natural environment favor the development of organic farming in this village.

[1] Organic farming systems and products are not always certified and are referred to as "non-certified organic farming or products". Non-certified organic farming systems are prevalent in developing countries although it is difficult to quantify to what extent.

[2] Environmental efficiency can be derived from different models such as that of Cuesta et al. (2009) in which environmental damage is analyzed through "bad output" modeling. In our case study, this strategy cannot be implemented because we have no information regarding the environmental damage caused by rice farming. For instance, we have no information on water or air pollution. For this reason, we focus only on the efficient use of an environmentally detrimental input, i.e., pure nitrogen.

[3] Guangxi Zhuang autonomous region is a predominantly ethically "Zhuang" region where economic development is low in terms of the national level. Sancha village is a typical Zhuang village with about 650 inhabitants.

[4] Data come from our household survey at the village-level and from the 2010 Guangxi Statistical Year Book at the provincial level.